

JOINT PROSTHESIS WITH INFINITELY POSITIONABLE HEAD

Background of the Invention

The present invention relates to joint prosthesis, and particularly to prosthesis having an articulating head component. More specifically, the invention relates to a system for achieving infinitely variable positions for the head component relative to a bone engaging portion of the prosthesis.

Repair and replacement of human joints, such as the knee, shoulder, elbow and hip, has become a more and more frequent medical treatment. Longer life spans mean that the joints endure more wear and tear. More sports activities mean greater likelihood of serious joint injuries. Treatment of injuries, wear and disease in human joints has progressed from the use of orthotics to mask the problem, to fusion of the joint, to the use of prostheses to replace the damaged joint component(s).

As the success rate for total or partial joint replacements has increased, so too has the need for modularity and universality in the joint prosthesis. Patient variety means that no single size or configuration of joint prosthesis will suffice. The physical dimensions of a patient's joint components vary, as well as the bio-mechanic relationship between these components. For instance, in a shoulder prosthesis, the relationship between the articulating humeral and glenoid components can be significantly different between patients. These relationships are especially important where only one component of the joint is being replaced and must integrate with the existing natural opposing joint component.

For instance, in many shoulder surgeries, only the humeral component is replaced, leaving the glenoid component intact. In this case, it is imperative that the articulating surface of the humeral component match the articulating surface of the glenoid component as perfectly as possible, both statically and dynamically. With a typical humeral prosthesis, version and inclination are adjusted by the geometry of the head of the prosthesis. In other words, certain

pre-determined head geometries are available that can be selected for a mating glenoid component. Absent an infinite variety of pre-determined head geometries, the resulting humeral prosthesis can often only achieve a best-fit relationship to the glenoid component of the shoulder joint.

In a typical surgical procedure, a trial component will be used to determine the optimum final component to be fixed to the bone. In most cases, the surgeon is able to make a good selection that fits the joint very well. However, in some cases, the accuracy of the fit cannot be determined until the surgery is completed and the patient has had an opportunity to exercise the repaired joint. Where significantly problems arise, a revision surgery may be necessary to replace an improperly sized or configured joint component. One typical revision surgery requires removal of the entire prosthesis from the bone and replacement with a different prosthesis.

There is a significant need for a joint prosthesis that is both modular and universal. Such a prosthesis would be easily manipulated during the surgery and capable of achieving nearly infinite version and inclination angles. Moreover, an optimum prosthesis would be readily available for modification in a revision surgery without having to remove the entire prosthesis.

Summary of the Invention

These and other needs of the prior art are met by the present invention in which a joint component is itself mounted to a bone engaging component of a prosthesis by an articulating mounting element. The articulating mounting element allows the joint component to adopt an infinitely variable range of angles in three dimensions relative to the bone engaging component.

In a preferred embodiment, the prosthesis is a humeral prosthesis for a shoulder replacement procedure. The humeral prosthesis includes a stem configured for engagement within the radius bone. The stem defines a tapered bore facing the glenoid component of the shoulder joint. A distal portion of the mounting element is configured to be initially mobile within the bore, while a proximal end is configured to carry the humeral joint component or trial. The mounting element can be articulated to find the optimum position for the humeral joint component. The mounting element can then be temporarily tightened to hold the humeral joint component in position to verify the version and inclination angles of the component. The mounting element can be finally tightened to complete the humeral prosthesis.

In one aspect of the invention, the mounting element is tightened by two mechanisms. In the first, the mounting element achieves a friction fit with the tapered bore. The second fixation mechanism includes a screw that is threaded into a threaded bore portion of the tapered bore in the stem. The screw bears against the mounting element to lock the element in position within the tapered bore. In accordance with a preferred embodiment of the invention, screw is internal to the mounting element and the proximal portion of the element provides a passageway to introduce and tighten the screw *in situ*.

The proximal portion of the mounting element defines a tapered surface that mates with a tapered feature of a head component for the humeral prosthesis. The head component can include an opening to access the passageway in the proximal portion of the mounting element, thereby providing access to the fixation screw.

The present invention contemplates a fully modular joint prosthesis. Thus, a number of joint components can be provided for interchangeable use to construct the prosthesis. For instance, a fixed mounting element can replace the articulating mounting element. Similarly, the head component for the joint prosthesis can be configured to mate directly with the stem, with the fixed mounting element or the articulating mounting element. The head component can also be modified to close the end of the passageway in the proximal portion of the articulating mounting element.

It is one object of the invention to provide a joint prosthesis that is both modular and universal. This object is achieved by features that permit infinitely variable positioning of a mating joint component relative to a bone engaging portion of the prosthesis.

Another object is to provide a prosthesis that is readily available for modification, whether during initial implantation or during a subsequent revision procedure. A further object of the invention is to combine these features without creating a profile or prominence greater than is achieved by current joint prostheses.

These objects and particular benefits of the invention will be appreciated upon consideration of the following written description together with the accompanying figures.

Description of the Figures

FIG. 1 is a side view of a prior art humeral prosthesis.

FIG. 2 is an enlarged cross-sectional view of a portion of a joint prosthesis in accordance with one embodiment of the invention.

FIG. 3 is a front view of an articulating mounting element used with the joint prosthesis shown in **FIG. 2**.

FIG. 4 is a front view of a fixation screw used with the joint prosthesis depicted in **FIG. 2**.

FIG. 5 is a bottom view of a head component of the joint prosthesis illustrated in **FIG. 2**.

FIG. 6 is a bottom view of an alternative head component for use with the joint prosthesis shown in **FIG. 2**.

FIG. 7 is a front view of an alternative mounting element that can substitute for the articulating mounting element in the joint prosthesis of **FIG. 2**.

Description of the Preferred Embodiments

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and described in the following written specification. It is understood that no limitation to the scope of the invention is thereby intended. It is further understood that the present invention includes any alterations and modifications to the illustrated embodiments and includes further applications of the principles of the invention as would normally occur to one skilled in the art to which this invention pertains.

A typical joint prosthesis of the prior art is illustrated in **FIG. 1**. The prosthesis **10** is the humeral component of a shoulder prosthesis that can be implanted in the humerus bone for articulating engagement with the natural glenoid or with a glenoid prosthesis. The prosthesis **10** includes a stem **12** configured to be implanted within the humerus bone in a conventional manner. The stem **12** forms a platform surface **15** that faces the glenoid component of the joint when the prosthesis is in its operative position. The platform surface **15** defines a tapered bore for use in mounting the articulating head component **14**. The head component includes a tapered post **18** that can be press-fit or friction-fit within the tapered bore **16** to firmly mount the head component to the stem **12**.

The prosthesis **10** can be a modular prosthesis, meaning that a number of stem and head geometries can be provided from which a selection can be made that most closely approximates the natural joint components of the patient. Thus, the angle of the platform surface **15** can be different among stems **12**. While all head components **14** will include a generally spherical bearing surface **19**, the orientation of this surface relative to the platform surface **15** can be changed. Specifically, the location of the post **18** relative to the bearing surface **19** can be offset from the center of the surface (i.e., an eccentric head). In some cases, the angle of the post can be different between head components **14**.

This modularity feature is improved by the present invention that introduces an articulating mounting element **30** between the stem **12** and a head

component **20**, as shown in **FIGS. 2-4**. In one embodiment of the invention, the mounting element **30** includes a proximal portion **33** that mates with the head component **20**. In a specific embodiment, the proximal portion **33** defines a tapered surface that is press-fit or friction-fit within a complementary bore **21** defined in the head component.

The mounting element **30** further includes an articulating portion **34** that can be preferably in the form of a spherical ball joint. The articulating portion is sized to achieve a press-fit engagement within the tapered bore **16** of the stem **12** when the portion **34** is pushed sufficiently far into the bore. The spherical shape of the articulating portion **34** allows the mounting element **30** to rotate about three dimensional axes **x**, **y**, **z**. Thus, the mounting element can rotate about its own axis (the **x** axis), pivot about a version axis (the **y** axis) or pivot about an inclination axis (the **z** axis). The mounting element **30** can rotate a full 360° about its own axis. However, the pivot range in the other two degrees of freedom is limited by contact between the articulating mounting element or the head component and the platform surface **15** of the stem **12**. The range of motion in these two degrees of freedom are maximized by the intermediate portion **35** connecting the articulating portion to the proximal portion. In particular, the intermediate portion **35** can be angled away from the articulating portion **34** to provide clearance as the mounting element is pivoted.

In one feature of the present invention, a second fixation capability is provided to augment the friction or press-fit between the articulating portion **34** and the tapered bore **16**. In particular, a machine screw **40** is provided that includes a threaded portion **46** configured to mate with a threaded bore **18** in the stem **12**. The bore **18** is concentrically disposed at the base of the tapered bore **16**. The screw **40** is introduced into the threaded bore **18** through the articulating mounting element **30**.

As shown in **FIG. 2**, the mounting element **30** defines a central passageway **36** that extends through the length of element and that is open at its proximal and distal ends. The passageway defines an internal bearing surface

38 at the distal end of the element, or more specifically at the base of the articulating portion **34**. The screw includes a head **42** that includes an underside surface **44** that is complementary with the internal bearing surface. These two surfaces form a spherical bearing interface that allows the mounting element **30** to experience its full range of angular motion without interference from the screw **40**, even when the screw is loosely threaded into the threaded bore **18**. The articulating portion **34** defines a relief **39** at the distal end of the passageway **36** to facilitate this full range of movement of the mounting element.

The passageway **36** in the mounting element allows introduction of the screw **40** through the mounting element and into the threaded bore **18**. The screw can be loosely threaded into the bore to permit movement of the mounting element. Once the proper position for the mounting element **30** has been achieved, the screw can be tightened using a tool engaged within the tool recess **43** on the head **42** of the screw. As the screw is tightened, it drives the articulating portion **34** deeper into the angled bore **16**, thereby fixing the mounting element against further articulation. The screw thus combines with the friction or press-fit feature to lock the construct.

It is contemplated that the articulating mounting element **30** can be utilized with the stem **12** engaged within the bone, such as the humerus. In order to determine the proper configuration for the joint prosthesis, a head component, such as component **20** is carried by the proximal portion **32** of the mounting element. As can be seen in **FIG. 2**, the head component **20** is closed over the passageway **36**, thereby preventing access to the screw **40** unless the head portion is removed. In one embodiment, a head component **70** can be provided as depicted in **FIG. 5**. This head component **70** includes a tapered bore **72** that is configured for mating engagement with the proximal portion **32**. However, unlike the head component **20**, the bore **72** includes an opening **74** at the proximal face of the component. Thus, the opening **74** provides complete access to the screw **40**, even when the head component **70** is mounted on the mounting element **30**.

In using the mounting element **30** of the present invention, the element **30** can be initially mated with a head component **70**. The component can be a final component or a trial. In the preferred embodiment, the two components mate by way of a socket taper as is known in the art. The mounting element **30**, with the head component mounted thereon, can be maneuvered to position the articulating portion **34** within the tapered bore **16**. The screw **40** can be introduced through the opening **74** and along the passageway **36** so that the screw can be threaded into the threaded bore **18** in the stem **12**.

The screw **40** can be loosely tightened so that the articulating portion **34** can rotate, but the screw head **42** offers some resistance to help hold the head component in position. The head component **70** can be manipulated as necessary to achieve an angular orientation that will mate efficiently with the opposite component of the joint (the glenoid component in the case of a shoulder prosthesis). The screw **40** can be tightened and loosened as necessary to hold the head component in position to verify proper mating fit between the joint components.

If it is determined that a different head component is needed, the component can be removed from the mounting element **34** without disturbing the position of the mounting element relative to the stem **12**. Once the proper head component has been selected and situated at its optimum orientation, the screw **40** can be fully tightened into the bore **18**.

The present invention contemplates a modular system that can accommodate a wide range of joint constructs. For instance, a head component **80** can be provided as shown in **FIG. 6**. This head component includes a mounting post **82** with a tapered engagement surface **84** that is configured to be mounted directly within the tapered bore **16**. The head component **80** can be used where no angular variations are required.

The head component **80** can also be press-fit into the passageway **36** of the mounting element **30**. In this case, the passageway is formed as a tapered bore, similar to the bore **16** in the stem **12**. With this specific embodiment, the

post **82** can define a bore therethrough that communicates with the passageway **36** in the mounting element to permit introduction of the screw **40** therethrough.

A further component of the modular system is the fixed mounting element **50** shown in **FIG. 7**. This fixed element includes a mounting portion **56** having a tapered surface **58** configured for press or friction-fit engagement with the tapered bore **16**. The proximal portion **50** can have a tapered surface **52** for engagement within the bore **21** of the head component **20** (**FIG. 2**), or within the bore **72** of the head component **70** (**FIG. 5**). As is apparent from **FIG. 7**, the mounting element **50** does not accommodate changes in version or inclination angle, the degrees of freedom of movement of the element being limited to the longitudinal axis of the element.

The mounting element **50** can include a bore **54** that can be tapered to receive the post **82** of the head portion **80** (**FIG. 6**). In addition, the bore can provide a passageway for introduction of a mounting screw, like the screw **40** depicted in **FIG. 4**. The bore can form a bearing surface **60** against which the surface **44** of the screw **40** bears to clamp the mounting element **50** to the stem **12**.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same should be considered as illustrative and not restrictive in character. It is understood that only the preferred embodiments have been presented and that all changes, modifications and further applications that come within the spirit of the invention are desired to be protected.

For instance, while the illustrated embodiments relate to a humeral component of a shoulder prosthesis, the connection element of the present invention can be utilized in other joints to engage a joint component to a bone engaging component of the prosthesis.

The preferred embodiment includes a machine screw **40** for final securement of the mounting element **30** to the stem by way of the mating

threaded bore **18**. Other forms of mechanical fastener are contemplated that can effect final fixation of the mounting element to the stem. For instance, a press-fit pin can be provided that is pressed into a complementary bore (in lieu of the threaded bore **18**). The pin would retain the configuration of the head **42** of the screw **40**, most particularly the spherical underside surface **44** and would operate to press the articulating portion **34** into the tapered bore **16**.

Furthermore, while the preferred embodiment contemplates angular adjustment capabilities in all degrees of freedom, the mounting element can be configured to limit angular movement to specific directions. For instance, instead of a spherical interface, the articulating portion **34** can include a flat side opposing a corresponding flat side to the bore **16** such that rotation of the portion **34** between the two flat sides is prohibited.